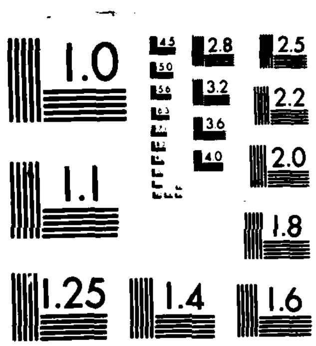
AD-A129 256 C-9A INTERIOR NOISE EVALUATION(U) AIR FORCE OCCUPATIONAL AND ENVIRONMENTAL HEALTH LAB BROOKS AFB TX C M JONES FEB 83 OEHL-83-101EH174BNA 1/1

UNCLASSIFIED F/G 20/1 NL

END
DATE FILMED
7-83
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

2

USAF OEHL REPORT

83-101EH174BNA

AD A129256

C-9A INTERIOR NOISE EVALUATION

FEBRUARY 1983

USAF Occupational and Environmental Health Laboratory
Aerospace Medical Division (AFSC)
Brooks Air Force Base, Texas 78235

NOTICES

When U.S. Government drawings, specifications, or other data are used for any purpose other than a definitely related Government procurement operation, the Government thereby incurs no responsibility nor any obligation whatsoever, and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise, as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

The mention of trade names or commercial products in this publication is for illustration purposes and does not constitute endorsement or recommendation for use by the United States Air Force.

Do not return this copy. Retain or destroy.

Please do not request copies of this report from the USAF Occupational and Environmental Health Laboratory. Additional copies may be purchased from:

National Technical Information Service
5285 Port Royal Road
Springfield, Virginia 22161

Government agencies and their contractors registered with the DTIC should direct requests for copies of this report to:

Defense Technical Information Center (DTIC)
Cameron Station
Alexandria, Virginia 22314

This report has been reviewed by the Public Affairs Office and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

William E Mabson

WILLIAM E. MABSON, Colonel, USAF, BSC
Commander

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER USAF OEHL Report 83-101EH174BNA	2. GOVT ACCESSION NO. A129256	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) C9A Interior Noise Evaluation		5. TYPE OF REPORT & PERIOD COVERED Final: 28 Apr-2 May 82 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) 1Lt Carolyn M. Jones		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS USAF Occupational and Environmental Health Laboratory, Brooks AFB TX 78235		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS USAF Occupational and Environmental Health Laboratory, Brooks AFB TX 78235		12. REPORT DATE February 1983 13. NUMBER OF PAGES 23
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

C-9A
Aircraft Noise
Interior Noise
Crew Noise Exp

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The USAF OEHL was requested by HQ MAC/SGPE to evaluate interior noise levels on the C-9A Nightingale aircraft during aeromedical evacuation operations because of subjective opinion that the cabin has become more noisy in recent years. Measurements were made on 18 regular working flights of the 57th Aeromedical Evacuation Squadron (AES), Scott AFB IL. Noise exposure data indicated hazardous noise levels in the rear of the cabin only. Crewmember noise exposures could be effectively limited by the use of hearing protection.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT NO. 83-101EH174BNA

USAF OCCUPATIONAL AND ENVIRONMENTAL

HEALTH LABORATORY

Brooks AFB, Texas 78235

C-9A Interior Noise Evaluation

February 1983

Prepared by:

Carolyn M. Jones

CAROLYN M. JONES, 1Lt, USAF, BSC
Consultant, Industrial Hygiene Engineer

Reviewed by:

William D. Christensen

WILLIAM D. CHRISTENSEN, Lt Col, USAF, BSC
Chief, Industrial Hygiene Branch

Approved by:

ARTHUR P. CALDWELL, Colonel, USAF, BSC
Chief, Consultant Services Division

Acknowledgements

The author gratefully acknowledges the assistance of the personnel of 375th AAW, Scott AFB IL, for their participation in this study. I would also like to thank Capt Alicia Poslosky, of the 57th AES, 1Lt Thomas Rau, formerly of AFAMRL/BBE, Mr Dan Lorch of McDonnell Douglas Corp, and Capt Peter Lurker of USAF OEHL/ECH, for their support in the completion of this project.

Table of Contents

List of Illustrations

I. INTRODUCTION

At the request of HQ MAC/SGPE, the USAF Occupational and Environmental Health Laboratory (USAF OEHL/ECH) evaluated interior noise levels on the C-9A Nightingale aircraft during aeromedical evacuation operations. The survey was conducted from 28 April-2 May 1982 by 1Lt Carolyn M. Jones. Measurements were made on 18 regular working flights of the 57th Aeromedical Evacuation Squadron (AES), Scott AFB IL.

II. BACKGROUND

The original request for this survey was made by the 375th Aeromedical Airlift Wing (375th AAW/SGS) following subjective opinion that the C-9A cabin has become more noisy in recent years. The McDonnell-Douglas C-9A is the standard aircraft for CONUS aeromedical evacuations. The concern was that Aeromedical Evacuation Crewmembers (AECMs) were being occupationally exposed to hazardous noise levels, and that crewmember to crewmember and crewmember to patient communication had become more difficult. The use of hearing protection on the C-9A needs close evaluation because communication is critical to patient monitoring. Furthermore, the study was done at this time because the C-9A is scheduled for overhaul in the near future, and if recommendations are made to quiet the cabin, those recommendations could be incorporated into the scheduled overhaul.

The McDonnell-Douglas C-9A Nightingale (the commercial version is the DC-9) came into the AF inventory in the late 1960s. It carries a crew of eight; pilot, copilot, additional crewmember (ACM), medical crew director (MCD), flight nurse, charge medical technician, and two additional medical technicians. The axial flow turbofan aircraft is powered by two Pratt and Whitney JT8D 9 engines. The C9-A is extensively modified for aeromedical evacuation duties. Interior configurations are changed as needed; all litter patients, combination of litter and ambulatory patients, or all ambulatory patients. This study was done on aircraft in the ambulatory/litter configuration (see Fig 1). Measurements were made on aircraft with tail numbers 878, 959, and 961.

This study involved extensive audio dosimeter measurements to determine the noise exposure of AECMs. A-weighted sound-level measurements were also taken throughout the aircraft for comparison with data from the AF Aerospace Medical Research Laboratory, Biodynamic Environment Branch (AFAMRL/BBE), USAF Bioenvironmental Noise Data Handbook, Volume 149 (1).

III. LITERATURE REVIEW

A. Previous Studies

Early in production flight tests of the DC-9, Douglas Aircraft Company, Inc., found that a few aircraft were excessively noisy in the aft two or three window seats. The problem was studied in detail and results were reported in 1967 by Van Dyke, et al. (2). Through analytical (computer-aided

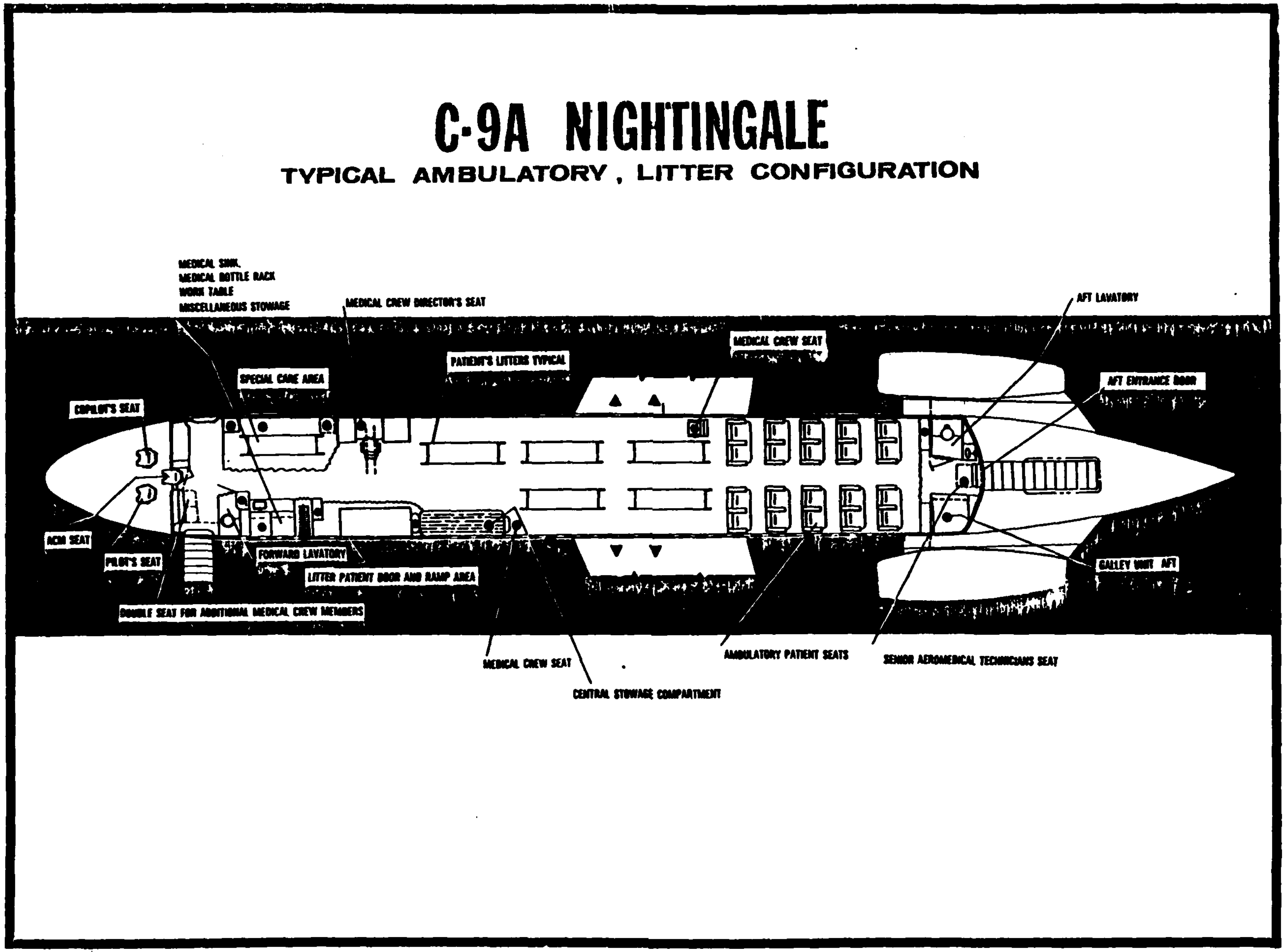


FIGURE 1. Typical ambulatory, litter configuration of the C-9A Nightingale

design) and experimental methods, it was found that the overall sound pressure in the aft cabin was a result of discrete frequency peaks at the two engine rotor frequencies. Peaks were generated by the low-speed rotor (N_1) at approximately 120 Hz, and by the high-speed rotor (N_2) at approximately 180 Hz. Testing showed that aft fuselage resonances occurred at both of the peak frequencies.

Various control methods were examined including modified engine mounts, application of damping material to bulkhead structures, and tuned vibration absorbers. The tuned vibration absorbers were determined to be the superior approach for effectiveness, ease of application, and cost. A reduction in overall sound-pressure levels of more than 10 decibels (dB) was achieved. The tuneable vibration absorbers are standard in the C-9A and routinely inspected and maintained, as per T.O. 1C-9A-6, "Scheduled Inspection and Maintenance Requirements, USAF Series C-9A Aircraft."

In 1970, the USAFSAM studied interior noise levels of the C-9A aeromedical evacuation aircraft (3). Octave-band data were gathered to determine the degree of speech interference and auditory risk associated with aeromedical evaculation duties. Conclusions from the this study (which predates AFR 161-35 standards) are; (a) noise levels in the aft end of the cabin would not produce permanent hearing loss, but may produce some degree of auditory fatigue (Temporary Threshold Shift); (b) seats in the last two rows should not be occupied by ambulatory patients or passengers unless load requires it; (c) and while speech intelligibility may be decreased because of the noise levels, it would be improved to an acceptable level with the use of disposable earplugs.

At the request of the Federal Aviation Administration (FAA), research was undertaken to investigate possible hearing damage to commercial and business pilots and crew from jet aircraft interior noise (4). Interior noise levels at cruise power were determined for conventional take-off and landing (CTOL) and short take-off and landing (STOL), narrow and wide body aircraft, including the DC-9. The problem of nonuniform daily aircraft crew schedules with respect to damage risk criteria was also examined, albeit with the Committee on Hearing Bioacoustics and Biomechanics (CHABA, 1965) criteria (which are more lenient than AFR 161-35 Standards). This study concluded: (a) none of the average (cruise) levels found in commercial jet aircraft exceeded CHABA recommended levels; (b) potential hearing loss evaluations may be based on interior cruise levels only for CTOL; and (c) utilizing CHABA recommendations, long exposure durations of 16 hours flight time should not lead to hearing loss if the average exposure duration for each work day per month does not exceed four hours.

B. AFAMRL Noise Data Handbook

Tables 1, 2, and 3 present data from the USAF Bioenvironmental Noise Data Handbook: C-9A In-Flight Crew/Passenger Noise (1). For information on equipment and procedures, contact AFAMRL/BBE, Wright-Patterson AFB OH 45433, AUTOVON 785-3605.

Table 1 presents weighted interior C-9 cruise noise levels at various locations throughout the aircraft. Table 2 presents octave-band noise levels and A-weighted levels while wearing ear protection at the charge medical technician's station and in row 1 during several phases of flight (take-off, climb, etc.). Table 3 presents Speech Interference Levels (SIL) during cruise at various aircraft locations.

TABLE 1

A-Weighted Overall Sound Level (OASLA in dBA) at Ear During Cruise*

LOCATION	OASLA	LOCATION	OASLA
Pilot	74	Row 3 Left Window Seat	81
Co-Pilot	74	Row 3 Left Aisle Seat	80
Flight Mechanic	76	Row 4 Left Window Seat	79
Additional Crewmember	79	Row 4 Left Aisle Seat	78
Flight Nurse	79	Row 5 Left Window Seat	79
dical Crew Director	79	Row 5 Left Aisle Seat	78
Second Medical Technician	78	Row 6 Left Window Seat	78
Third Medical Technician	80	Row 6 Left Aisle Seat	77
Charge Medical Technician	81	Row 7 Left Window Seat	78
Medical Sink Area	78	Row 7 Left Aisle Seat	79
Aft Pantry Area	83	Row 8 Left Window Seat	77
Forward Pantry Area	83	Row 8 Left Aisle Seat	77
Aft Lavatory	81	Row 9 Left Window Seat	79
Row 1 Left Window Seat	88	Row 9 Left Aisle Seat	78
Row 1 Left Aisle Seat	84	Aft Right Litter	78
Row Centerline	83	Forward Right Litter	78
Row 2 Left Window Seat	81		
Row 2 Left Aisle Seat	82		

*AFAMRL/BBE, Wright-Patterson AFB, Ohio, USAF Bioenvironmental Noise Data Handbook, Vol. 149

IV. METHODOLOGY

A. Equipment

Sound-level meter readings were made with the GenRad Model 1982 Precision Sound Level Meter, OEHL SN 01265. Noise exposure readings were made with the GenRad Type 1954 Personal Noise Dosimeter, OEHL SN 00257, 00268, 00278, 00279, and three on loan from the USAF School of Aerospace Medicine (USAFSAM), which were not serialized, but identified during the survey as USAFSAM 1, 2, and 3. Precalibration was done with the GenRad 1986 Omnical, OEHL SN 02254. Field calibration was done with the GenRad 1562-A Permissible Sound Level Calibrator, OEHL SN 22474.

TABLE 2

Octave-band Noise Levels and A-Weighted Levels with E.A.R. Brand Earplugs During Different Phases of Flight (in dB)*

Location/Condition	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1K Hz	2K Hz	4K Hz	8K Hz	Flat Hz	Without Earplugs (dBA)	W/ear-plugs (dBA)
Charge Med Tech/Taxi	87	83	96	76	72	68	66	63	67	97	80	53
Take-Off Roll	95	90	109	93	85	81	75	71	72	110	94	67
Climb	86	87	111	92	85	79	74	70	70	112	96	69
Cruise	78	83	91	81	77	76	72	66	63	92	81	51
Approach	86	84	90	79	78	73	69	67	74	92	80	50
Landing Roll	93	94	99	97	96	90	78	73	74	103	96	64
Row 1 Left Window Seat												
Taxi	82	86	109	83	75	72	79	66	62	109	92	66
Take-Off Roll	93	95	104	104	84	77	72	69	69	114	99	72
Cruise	78	91	101	91	82	78	71	63	60	102	88	60
Descent	89	92	102	88	79	71	67	67	66	103	88	61
Approach	87	92	101	88	81	77	73	74	66	102	89	60
Landing Roll	95	98	105	100	97	85	76	70	73	107	97	67
Row 1 Left Aisle Seat												
Climb	82	91	111	95	83	76	71	67	66	111	96	68

*AFAMRL/BBE, Wright-Patterson AFB, Ohio, USAF Bioenvironmental Noise Data Handbook, Vol. 149

TABLE 3

Speech Interference Levels During Cruise (SIL in dB)

LOCATION	SIL (dB)	LOCATION	SIL (dB)
Pilot	68	Row 1 Left Aisle Seat	74
Co-Pilot	67	Row 2 Left Window Seat	69
Flight Mechanic	69	Row 3 Left Window Seat	69
Additional Crewmember	72	Row 4 Left Window Seat	68
Flight Nurse	71	Row 5 Left Window Seat	69
Medical Crew Director	71	Row 6 Left Aisle Seat	69
Second Medical Technician	70	Row 7 Left Window Seat	69
Third Medical Technician	70	Row 8 Left Window Seat	69
Charge Medical Technician	73	Row 9 Left Window Seat	70
Aft Pantry Area	74	Aft Right Litter	70
Row 1 Left Window Seat	74	Forward Right Litter	70

*SIL = Arithmetic Average of 500, 1000, 2000, 4000 Hz Octave Bands Octave-Band Data from AFAMRL/BBE, Wright-Patterson AFB OH, USAF Bioenvironmental Noise Data Handbook, Vol. 149

B. Procedure

Noise dosimeters were provided to medical crewmembers prior to the first flight of the day, and worn between 3 and 12 hours. Each dosimeter was attached to the crewmember's belt, and the microphone fastened to the collar to collect noise exposure data at the ear. Area dosimeter readings were also taken at seated head level at the left aisle seat in row 1 and at the MCD's station (Fig 1).

Sound-level meter readings were taken during climb, cruise, and descent at the charge medical technician's seat, at the left aisle seat in rows 1 and 5, at the litter area, MCD's station, and at the doorway to the cockpit.

V. RESULTS

A. Sound-Level Meter Readings

Noise measurements were accomplished during the entire flight, but only cruise noise levels are comparable from one study to another because take-off, climb, and descent measurements vary with flight parameters such as power settings, altitude, etc. However, other phases of flight were timed to roughly determine their contribution to overall noise exposure. Table 4 presents A-weighted cruise sound levels at various locations throughout the aircraft for twelve flights. Table 5 lists averaged times for several phases of flight. Use of those times as a "typical" flight should be interpreted as a guide only because flight parameters will vary greatly.

TABLE 4

A-Weighted Cruise Noise Levels (dBA)

	Day 1 Tail #959				Day 2 Tail #961				Day 3 Tail #878			Day 4 #878	
	FLIGHT*												
Location	1	2	3	4	5	6	7	8	9	10	11	12	Energy Avg**
Charge Medical Technician	83	86	84	86	86	86	85	86	85	84	84	87	85
Row 1 Left Aisle Seat	83	84	83	84	85	85	86	86	84	85	85	84	85
Row 5 Left Aisle Seat	79	82	81	82	83	84	84	85	82	82	82	82	83
Aft Litter	80	82	81	81	83	84	83	85	82	82	83	78	82
Medical Crew Director	80	82	81	81	83	84	84	85	83	83	83	79	83
Additional Crewmember	80	82	80	82	80	84	83	84	84	83	83	79	82

*Flight Specifications:

1. Scott AFB IL - Buckley ANG CO: 35,000 ft cruise altitude
2. Buckley ANG CO - Hill AFB UT: 31,000 ft cruise altitude
3. Hill AFB UT - Malmstrom AFB MT: 35,000 ft cruise altitude
4. Fairchild AFB WA - McChord AFB WA: 28,000 ft cruise altitude
5. Travis AFB CA - McChord AFB WA: 31,000 ft cruise altitude
6. McChord AFB WA - Fairchild AFB WA: 25,000 ft altitude
7. Malmstrom AFB MT - Mt Home AB ID: 28,000 ft altitude
8. Mt Home AFB ID - Hill AFB UT: 25,000 ft cruise altitude
9. Buckley ANG CO - Hill AFB UT: 31,000 ft cruise altitude
10. Mt Home AFB ID - Malmstrom AFB MT: 33,000 ft cruise altitude
11. Malmstrom AFB MT - Whidbey Island NAS WA: 31,000 ft cruise altitude
12. Travis AFB CA - Kelly AFB TX: 33,000 ft cruise altitude

**Energy averaging is necesary when averaging logarithmic values such as decibels.

$$\text{Energy Avg} = 10 \log (1/n) \sum_{i=1}^{n} 10^{L_i/10}$$

where L_i = an A-weighted sample

n = number of samples

TABLE 5

"Average" Time for Different Flight Conditions

Phase	Avg. Time (Min)*
Taxi	3.7
Take-off Roll	2.5
Climb	13.0
Descent	17.4
Landing Roll	<.5

*Average time was determined by measuring each phase with a stopwatch and arithmetically averaging the results.

B. Noise Dosimeter Readings

Audio dosimeter measurements presented in Table 6 show the percent of allowable exposure for the five AECMs (medical crew director, flight nurse, charge medical technician, second and third medical technicians) during four days' flights. Table 7 gives the total exposure time for each day, and Table 8 presents the A-weighted Equivalent Continuous Level (ECL) for each day. Table 9 includes additional dosimeter measurements taken on a fictious "passenger" in row 1, aisle seat, and for comparison, on a ficticious MCD assuming continuous duty at the station for the flight's duration.

VI. DISCUSSION

A. Hazardous Noise Exposure

1. AFR 161-35 defines Hazardous Noise as exposure equal to more than 84 decibels A-weighted sound pressure level for 8 hours in any 24-hour period or its equivalent exposure at higher levels for shorter times according to Table 10 below. A Hazardous Noise Area is a work area where the combination of sound-pressure level (dBA) and duration of daily exposure is more than the values of Table 10. Hazardous Noise Exposure is actual exposure of personnel to the same. Routine Exposure to Hazardous Noise is where an individual, within one work week, would be exposed to noise at such levels and for such times that the sum of the ratios of actual exposure durations over the limiting exposure durations is more than one.

TABLE 6

Percent Allowable Exposure for Each Crewmember (%)

Crewmember	Day 1	Day 2	Day 3	Day 4
Medical Crew Director	130	120	130	37
Flight Nurse	140	181	111	46
Charge Medical Technician	277	167	201	84
2nd Medical Technician	149	*	100	35
3rd Medical Technician	282	484	93	52

*Crewmember declined participation

TABLE 7

Total Dosimeter Exposure Time for Each Flight (in Hrs)

Crewmember	Day 1 "Normal"	Day 2 "Short"	Day 3 "Short"	Day 4 "Very Short"
Medical Crew Director	11:55	9:20	7:32	3:45
Flight Nurse	11:40	9:31	7:23	3:41
Charge Medical Technician	12:05	9:24	7:28	3:39
2nd Medical Technician	12:15	*	7:23	3:38
3rd Medical Technician	12:20	9:29	7:25	3:18

*Crewmember declined participation

TABLE 8

A-Weighted Equivalent Continuous Level (ECL* in dBA) for Each Crewmember

Crewmember	Day 1	Day 2	Day 3	Day 4	Energy Avg.
Medical Crew Director	84	85	87	83	85
Flight Nurse	84	87	86	84	85
Charge Medical Technician	88	87	89	88	88
2nd Medical Technician	84	**	85	83	84
3rd Medical Technician	88	93	84	86	89

$$*\text{ECL} = 13.29 \log \left[\left(\frac{D}{100}\right)\left(\frac{8}{T}\right)\right] + 84$$

where D = % Allowable Exposure
T = Exposure Time in Hours

**Crewmember declined participation

TABLE 9

Area Dosimeter Results at Medical Crew Director's Station and Row 1

Position and Day	% Dose	ECL (dBA)	Total Time (Hrs)
Medical Crew Director's Station			
Day 2	48	81	7:40
Day 3	77	83	7:11
Row 1 Left Aisle Seat			
Day 2	115	86	7:34
Day 3	115	86	6:08

TABLE 10

Limiting Values for Total Daily Exposure. Duration of Total Daily Exposure Time (T) as a Function of A-Weighted Sound Level (dBA)

Sound Level, dB(A) Above 115 Ear	T* (Minutes) Protection Required	Sound Level, dB(A)	T* (Minutes)
115	2.2	96	60
114	2.7	95	71
113	3.2	94	85
112	3.8	93	101
111	4.5	92	120
110	5	91	143
109	6	90	170
108	8	89	202
107	9	88	240
106	11	87	285
105	13	86	339
104	15	85	404
103	18	84	480
102	21	83	571
101	25	82	679
100	30	81	807
99	36	80	960
98	42	79	1142
97	50	78	1358
		Below 78	No limit

*Rounded to nearest 0.1 below 5 minutes and nearest integer above 5 minutes.
Table V, AFR 161-35, Hazardous Noise Exposure, 9 Apr 83 (9)

where:

$$T = \frac{16}{2 \exp\left(\frac{L-80}{4}\right)} \qquad \text{where } L = \text{A-weighted sound level}$$

2. At cruise, AFAMRL found noise levels in the rear of the cabin between 81 and 88 dBA (see Tables 1, 2, and 4). The USAF OEHL measurements ranged from 83-87 dBA, with an energy averaged value of 85 dBA. Therefore, while the cruise levels are not extremely high, they do consistently exceed 84 dBA. Forward of row 1, the cruise noise levels drop to 76-82 dBA (AFAMRL) or 82 dBA (USAF OEHL). From the AFR 161-35 definitions given above, it can be seen that at C-9A cruise power, noise levels in the aft cabin are classified as hazardous, while levels forward of row 1 are not. The cockpit noise level of 74 dBA is well below 84 dBA and, therefore, pilot exposure is not examined any further. The results of both AFAMRL and USAF OEHL measurements agree with the previous studies.

From the octave-band data in Table 2, and the McDonnell-Douglas study (2), the dominance of the low frequency noise (125 and 250 Hz range) contribution is evident. It is our belief that the primary aft cabin noise source is still engine rotor noise transmitted to the aft fuselage via the pylons. Subjectively, noise levels can be aggravated by the presence of a "beat" phenomenon when the rotors of both engines are not syncronized. However, the beat is more annoying than hazardous. In the forward part of the cabin, engine noise is negligible and sound levels are a result of exterior flow conditions and interior air conditioning.

3. During C-9A ground operations, aircraft electrical, hydraulic, air conditioning and pneumatic power is supplied by an Auxiliary Power Unit (APU) installed in the bottom of the fuselage in front of the aft stairway. When the aft door is closed, the noise level at the charge medical technician station is 73 dBA. However, at the bottom of the aft stairs, the level is 92 dBA, and is a potential source of hazardous noise exposure for the AECMS involved with off-loading and on-loading patients from the rear. Furthermore, the doors are frequently left open while the aircraft is being set up prior to the first flight of the day.

4. Audio dosimeter results were given in Tables 6-9. The first day's data were for a "normal" flight, i.e., approximately 12 hours long with six stops. The second and third day's measurements were shorter since no measurements were made during the final flight of the day. They were 9.5 and 7.5 hours long and had six and five stops, respectively. Measurements on the fourth day were for approximately 3.5 hours because the USAF OEHL personnel departed at Kelly AFB TX. (The flight continued on for several more stops.) Exposures for the "short" days can be extrapolated out for a full day's exposure.

Based on dosimeter measurements presented in Table 6, application of USAF noise exposure criteria from AFR 161-35 showed that the charge medical technician and third medical technician were clearly overexposed to hazardous noise during the performance of their duties. The MCD, flight nurse and second medical technician had borderline exposures. The percent dose for all AECMs was exacerbated by the long duty day. The effect of the long duty day and nonconventional work schedule will be discussed in further detail below. The charge medical technicial and third medical technician received a high noise exposure from the aft cabin environment and the APU during ground operations. However all AECMs moved throughout the cabin as a normal part of their duties and, therefore, were subject to the hazardous noise levels. For example, even though the total flight exposure at the MCD station for the stationary dosimeter was less than 100%, the MCD still had an average equivalent continuous level of 85 dBA for the sample period. The value of 100% used to indicate the maximum permissible exposure for a workday.

From the area dosimeter in row 1, it is evident that a patient or passenger sitting in row 1, aisle seat for approximately 7 1/2 hours of flight and ground time would have greater than 100% exposure. The one-time effect of this exposure should not be a problem, except for the patient who is going for evaluation following a threshold shift.

5. AFAMRL measured C-9A noise levels during all phases of flight at the worst locations, i.e., the charge medical technicians's station and row 1, (see Table 2). It can be seen that noise may reach high levels, particularly on take off and in landing roll during engine reverse thrust. Because of the short duration of these phases when compared with cruise times (see Table 5), the high noise levels do not constitute a hazard for the C-9A crewmembers, except in the previously named locations. In the aft cabin, take-off, climb, descent, and landing noise levels do contribute significantly to crewmember noise exposure.

6. It was mentioned earlier that the nonuniform work schedule of AECMs creates special problems. AFR 161-35 noise exposure standards are based on an 8-hour per day, 40-hour per week, occupational exposure, with the assumption that the nonoccupational exposure time will allow for recovery of temporary threshold shifts. CONUS aeromedical evacuation crews normally work three consecutive days for 12 or more hours per day. This schedule would give an AECM 36 hours of noise exposure in only 3 days; far more than a traditional work schedule. Furthermore, as seen in Table 11, total weekly and monthly noise exposures from flight duties vary considerably. Because there is currently a shortage of scientific data on this exposure issue, the levels specified in AFR 161-35 will continue to be used.

From data supplied by the 57th AES/SGNS, (5) AECM's total monthly flying hours vary considerably. In the 73rd AES (nurse and medical technicians combined) only 13.4% fly more than 40 hours per month because it is a reserve unit. In the 57th AES, 48.2% of the flight nurses and 58.9% of the medical technicians fly more than 40 hours per month. Approximately 1.8% of the flight nurses and 4.5% of the medical technicians fly more than 80 hours per month.

Nonflying duties include Stan/Eval, Training, CNO, Drug Room, Scheduling, Patient Airlift Center (PAC), and Special Equipment. Those medical technicians (18 in the 57th AES) working for Special Equipment have additional flightline noise exposures resulting from equipment transfer to and from aircraft. In spite of AECM noise exposures, two past studies have shown no identifiable noise induced hearing losses (6,7). Both studies reviewed audiometric data available from the USAF Hearing Conservation Program. The first study reviewed one year's audiograms for flight nurses on flying status. The second study looked at three year's audiograms for both flight nurses and medical technicians. The only hearing losses noted were attributed to presbycusis (impairment of hearing from age).

7. Currently, Military Airlift Command has no requirement that hearing protection be worn on C-9A aeromedical evacuation flights. Air Force Pamphlet 164-2, Aeromedical Evacuation Nursing, Chapter 11 (8) contains information on noise in aeromedical evacuation operations, but it only suggests rather than specifies the use of hearing protection. Hearing protection in the form of foam earplugs is available to all crewmembers, passengers and patients on C-9A flights. From observation during this study, it appeared that some crews were faithful in their wear of earplugs, while others only wore them sporadically.

Table 11

No. of hours flown per month for AECMs.

	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	>80
73rd AES Flight Nurses & Med Techs									
Number	222	130	62	46	29	23	5	8	6
Relative %	41.8	24.5	11.7	8.7	5.5	4.3	.9	1.5	1.1
Cumulative %	41.8	66.3	78.0	86.6	92.1	96.4	97.4	98.9	100
57th AES Med Techs									
Number	6	14	13	13	13	20	20	8	5
Relative %	5.4	12.5	11.6	11.6	11.6	17.9	17.9	7.1	4.5
Cumulative %	5.4	17.9	29.5	41.1	52.7	70.5	88.4	95.5	100
57th AES Flight Nurses									
Number	19	22	23	22	21	24	19	13	3
Relative %	11.5	13.3	13.9	13.3	12.7	14.7	11.5	7.8	1.8
Cumulative %	11.5	24.7	38.6	51.8	64.5	78.9	90.4	98.2	100

Ref: 57th AES (MAC)/SGNS (5)

B. Speech Interference Levels

1. AFR 161-35 defines those noise levels which determine the effectiveness of voice communication (see Fig 2). Both dBA noise levels and Speech-Interference Levels (SIL) can be used together with the distance from the speaker to listener to determine voice levels required for communication. The SIL is the arithmetic average of the sound-pressure levels in the 500, 1000, 2000, and 4,000 Hz octave bands, i.e., the speech range.

2. Table 3 gives SIL values for the C-9A at cruise for several locations throughout the aircraft. With the exception of the very back of the cabin, the C-9A SIL levels indicate no problem for speech communications. At distance of 2 ft between speaker and listener, the litter area requires only a "raised voice." The rear of the cabin (row 1 and charge medical technician station) requires a "very loud voice" at a 2 ft distance, and consequently, is the only cabin area where any speech difficulties are expected. Temporary communication difficulties throughout the cabin may be experienced during take-off and landing operations, but those durations are very short. Crewmembers should have no difficulty hearing the pilot's or MCD's chimes.

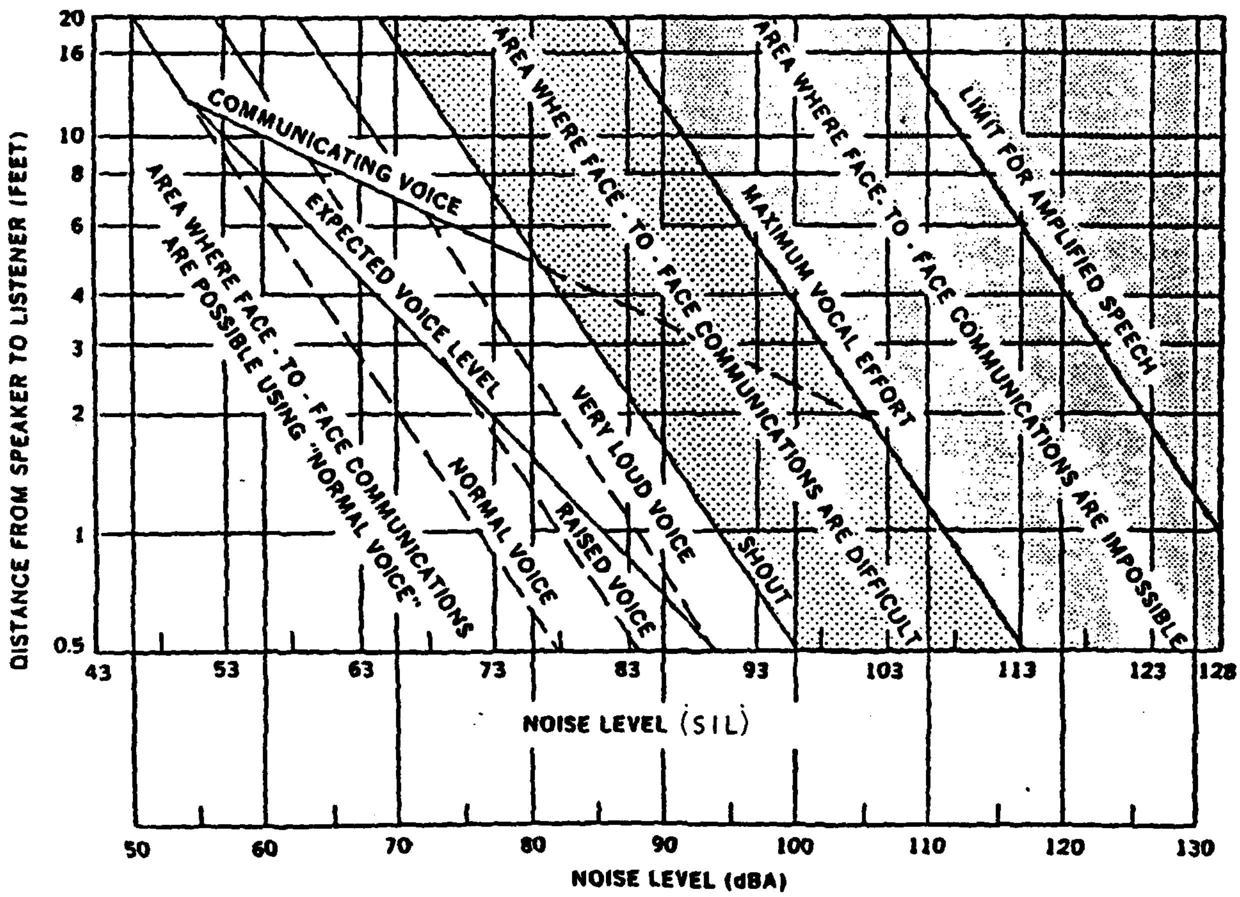
3. Because crewmembers in the aft cabin should be wearing earplugs, the question of communication in noise while wearing hearing protection may arise. Several studies have been done on this subject (10, 11, 12). In summary, it has been found that for persons with normal hearing, the wearing of hearing protectors does not degrade speech intelligibility and may effect a slight improvement. If worn only by the speaker, intelligibility may decrease because the speaker's speech level will be reduced. When both speaker and listener wear protection, speech intelligibility is at least the same as that for both individuals wearing no protection.

VII. CONCLUSIONS

A. Noise levels measured at various crewmember positions by the USAF OEHL on the C-9A were similar to previous studies conducted by AFAMRL, USAFSAM and McDonnell-Douglas.

B. Noise levels at the charge medical technician's station and at the seats in row 1 were found to be hazardous during cruise. By definition, those locations are Hazardous Noise Areas. Cruise levels elsewhere in the aircraft were not found to be hazardous. Take-off and landing noise levels exceed 84 dBA, but only for very short durations.

C. Noise exposure data, determined by dosimeter measurements, indicated that the MCD, flight nurse, and second medical technician had borderline exposures, exaggerated by their long duty day. However the charge medical technician and the third medical technician consistently exceeded their allowable noise exposure.



NOTE: The effects of varying noise-exposure levels on satisfactory face-to-face speech communication are expressed here in terms of voice level and distance between talker and listener.

FIGURE 2. Effectiveness of Voice Communication

D. Crewmember to crewmember and crewmember to patient communications were satisfactory. At a distance of 2 feet, the litter area required only a "raised voice" and, at worst case, row 1 required a "very loud voice," for adequate communication.

VIII. RECOMMENDATIONS

The following recommendations are made in order to reduce potential exposure to hazardous noise on the C-9A:

A. The consistent and conscientious wear of hearing protection, by crewmembers, is the single most important recommendation. The noise levels achieved at the ear when foam earplugs (normally supplied on the C-9A) are worn are given in Table 3. Hearing protection is particularly important:

1. When the crewmember is in or behind row 1 (see para V.A.2. and V.A.4.);

2. for the charge medical technician during take-off and landing roll (see para V.A.5. and Table 2);

3. and when the aircraft is on the ground and the doors are open, or the crewmember is outside while the APU is running (see para V.A.3.).

B. Strengthen the annual briefing on hazardous noise to encourage self-motivation in the wearing of hearing protection. This requirement includes Air Force Reserve personnel (see AFR 161-35, para 14.b.).

C. Considering the nonuniform work schedule of crew members, personnel should be encouraged to recover during the rest overnight in a relatively quiet environment (less than 70 dBA IAW AFR 161-35) for a period at least as long as the exposure duration (see AFR 161-35, Table 5 footnote).

D. Crewmembers whose nonflying duties also involve hazardous noise exposure must be cognizant of the additional potential for hearing loss. The flight surgeon must also be made aware of this greater risk. The need for hearing protection in the nonflying duty should be emphasized (see para V.A.6.).

E. Although the aft cabin is a Hazardous Noise Area, no additional design or engineering modifications or noise treatments are recommended. Hazardous noise exposure can be effectively limited by the use of hearing protection.

F. Whenever patient load permits, the seats in row 1 should not be used. When they must be used, aisle seats should be used first, and hearing protection should be strongly encouraged during the entire flight (see para V.A.4.).

References

1. Rau, Thomas H., USAF Bioenvironmental Noise Data Handbook: C-9A In-Flight Crew/Passenger Noise, Air Force Aerospace Medical Research Labortory, AMRL-TR-75-50, Vol. 149, Aerospace Medicine Division (AFSC), Wright-Patterson AFB, Ohio (1982).

2. Van Dyke, J. Jr., J. Schendel, C. Gunderson, and M. Ballard, "Cabin Noise Reduction in the DC-9," Presented at AIAA Commercial Aircraft Design and Operation Meeting, Paper No. 67-401, June 1967.

3. Gasaway, Donald C., Noise Associated with Operation of the C-9A (Aeromedical Evacuation) Aircraft. USAF School of Aerospace Medicine, USAFSAM TR 70-63, Aerospace Medicine Division (AFSC), Brooks AFB, Texas (1970).

4. Pearsons, Karl S. and John F. Wilby, Possibility of Hearing Loss from Exposure to Interior Aircraft Noise, FAA-AEE-81-15, Federal Aviation Administration, Office of Environment and Energy, Washington D.C. (1982).

5. 57 AES/SGNS (HQ MAC) Letter, "Flying Hours C-9A Noise Exposure Survey," 7 Jun 82, Scott AFB IL.

6. Smith, Cynthia, A Comparison of Hearing Levels of Flight Nurses Before and During Flying Assignments. USAF School of Aerospace Medicine, Aerospace Medicine Division (AFSC), Brooks AFB, Texas. (1976).

7. Ryan, Mary Gene Guzinski, Can I Hear You? A Descriptive Longitudinal Study of Hearing Levels of Aeromedical Technicians and Flight Nurses. The University of Texas Health Science Center at Houston, School of Public Health, Texas. (1980).

8. AFP 164-2, Aeromedical Evaluation Nursing. Washington D.C., Department of the Air Force, 1982.

9. AFR 161-35, Hazardous Noise Exposure, Washington D.C., Department of the Air Force, 1982.

10. Abel, Sharon M., Peter W. Alberti, Caroline Haythornthwaite, and Krista Riko, "Speech Intelligibility in Noise: Effects of Fluency and Hearing Protector Type." Journal of the Acoustical Society of America. 71:708-715 (1982).

11. Howell, K. and A.M. Martin, "An Investigation of the Effects of Hearing Protectors on Vocal Communication in Noise." Journal of Sound and Vibration. 41:181-196 (1975).

12. Kryter, K.D., "Effects of Ear Protective Devices on the Intelligibility of Speech In Noise." Journal of the Acoustical Society of America. 18:413-417. (1946).

DATE
ILME